Blueprint for NAS Modernization

An Overview of the National Airspace System (NAS) Architecture Version 4.0
January 1999

Letter from the Administrator

Why Modernize?

What's the NAS Architecture?

How will the NAS Evolve?

Partnership

Back to NAS Architecture

Back to ASD

FAA Homepage

| Navigation | Communication | Surveillance | Aviation Weather | Avionics
| Free Flight Phase 1 | Operational Planning |
Airport Surface Operations | Departure/Arrivals | En Route/Oceanic |

NAS Modernization

What's in the National Airspace System (NAS)?

The NAS includes more than 18,300 airports, 21 air route traffic control centers (ARTCC), 197 terminal radar approach control (TRACON) facilities, over 460 airport traffic control towers (ATCT) and 75 flight service stations, and approximately 4,500 air navigation facilities. Several thousand pieces of maintainable equipment including radar, communications switches, ground-based navigation aids, computer displays, and radios are used in NAS operations. NAS components represent billions of dollars in investments by the Government. Additionally, the aviation industry has invested significantly in ground facilities and avionics systems designed to use the NAS.

The NAS relies on the FAA's 48,000 employees to provide air traffic control, flight service, security, field maintenance, certification, system acquisition, and other essential services. On the user side, there are more than 616,000 active pilots operating over 280,000 commercial, regional, general aviation, and military aircraft.

– Excerpts from the FAA Administrator's Fact Book (December 1998)

Accommodating Aviation's Growth and Replacing Aging Equipment

America's aviation industry is soaring into the 21st Century with projected increases in business, recreation, and personal travel. U.S. airlines alone expect that they will carry twice as many passengers by the year 2015 than they do today.

In order to manage this increased load on the National Airspace System (NAS), the air traffic control system and supporting services must be state-of-the-art, led by a coordinated long-term modernization effort.

Aviation users and service providers agree that, with today's NAS capabilities and tomorrow's increased demands, the need to modernize is urgent. A long-range modernization plan, backed by adequate and stable funding, must be implemented.

State of the Current NAS

The NAS is a complex collection of facilities, systems, equipment, procedures, and airports operated by thousands of people to provide a safe and efficient flying environment.

Although the NAS is among the safest aviation systems in the world, our air traffic control system is aging and behind in technology. There are, for example, computers that are

Previous Main Next

NAS Architecture

Providing an Advanced, Integrated, and Safe Aviation System

NAS Architecture Version 4.0 is a comprehensive document, supported by a relational database, detailing FAA's services from today through the year 2015.

The NAS Architecture is derived from aviation community recommendations that identified the operational concepts for a safe and more efficient NAS. These recommendations were evaluated based on projected funding levels, availability of technology, and achievable schedules.

Based on this evaluation, the FAA developed a set of architecture objectives to maximize user benefits by means of new hardware/software systems, facilities, procedures, and enhancements to existing systems. The result of this collaborative effort is a long-range aviation plan that provides improved services, technology, and safety for all NAS users and the flying public.

Who Was Involved in the Architecture Work?

Development of the NAS Architecture began in 1995, when RTCA, an advisory group to the FAA, convened Task Force 3 on Free Flight to determine the necessary changes in NAS operations to meet the needs of the aviation industry.

Over the past several years, hundreds of representatives – from airlines, general aviation, military, pilot associations, air traffic control associations, airports, aviation product manufacturers, government contractors, and international organizations – participated in the future design of the NAS through Government/Industry forums, architecture working groups, and many other feedback opportunities.

Key influences on the architecture included the 1996 White House Commission on Aviation Safety and Security, which recommended that the FAA accelerate modernization of the NAS, and the 1997 National Civil Aviation Review Commission, which recommended funding and performance management methods for implementing NAS modernization.

Previous Main Next

NAS Evolution

Building on Capabilities with Seamless Transitions

The NAS Architecture is the roadmap for evolutionary modernization. It sustains current NAS operations, while new technology and procedures are introduced and then gradually expanded, in a plan to meet system safety needs and improve services to the users.

These changes are evolutionary to allow a smooth transition from one technology to another, sufficient time for users to equip, and realistic schedules for service providers to test, train for, and deliver services.

The NAS Architecture accounts for changes required in procedures, training, airspace design, and certification of both the ground systems as well as the avionics. All changes must work together to enable a new capability to be realized by the users or service providers.

This section identifies the evolution across the NAS by time phase and phase of flight. By grouping the changes within the phase of flight, an overview of the interrelationships is presented.

Previous Main Next

Partnership

Essential Collaboration for National Growth and Enhanced Safety

With domestic and global trade and travel growing, aviation is a vital component of the U.S. and international economy.

The NAS Architecture sets the direction for the U.S. to manage expected air traffic growth and enhance safety based on the aviation community's Free Flight operational concept.

Flying without the constraints of today's structured routes and airspace will be possible by new decision support tools for controllers, advanced cockpit avionics for improved awareness and navigation, GPS augmentation, digital air-ground communications, and a dynamic collaborative decision-making process. Capabilities will build on each other throughout the three time phases of modernization to achieve the Free Flight concept.

The FAA and NAS users have jointly decided which capabilities offer advantages to the U.S. aviation system and the Free Flight environment and, based on costs and maturity of the technology, when they should be introduced.

Transition to this modernized NAS will be filled with challenges. Technology improvements, funding levels, and other factors will impact the course of modernization. In addition, global interoperability of technology and harmonization of procedures are essential for continuity of operations and avionics investments. As opportunities are identified, the FAA and NAS users will decide together on the future course.

Through this Government/Industry partnership and participation in the global aviation community, the FAA will provide a safer, more secure, and more efficient airspace system for the 21st Century.

Previous Main

Communications

Controller-pilot data link communications (CPDLC) provides for the exchange of critical and non-critical data communication messages between the controller and pilot. CPDLC greatly expands current data capabilities and provides controllers and pilots with a means to communicate routine and repetitive messages.

Improving Quality and Reliability through Integrated Digital Communications

Air traffic management depends on timely and accurate transmission of information during flight planning, in flight, and for airport operations. With the projected growth in air traffic, today's communications systems must be modernized to handle the additional demand and the need for faster and clear transmissions.

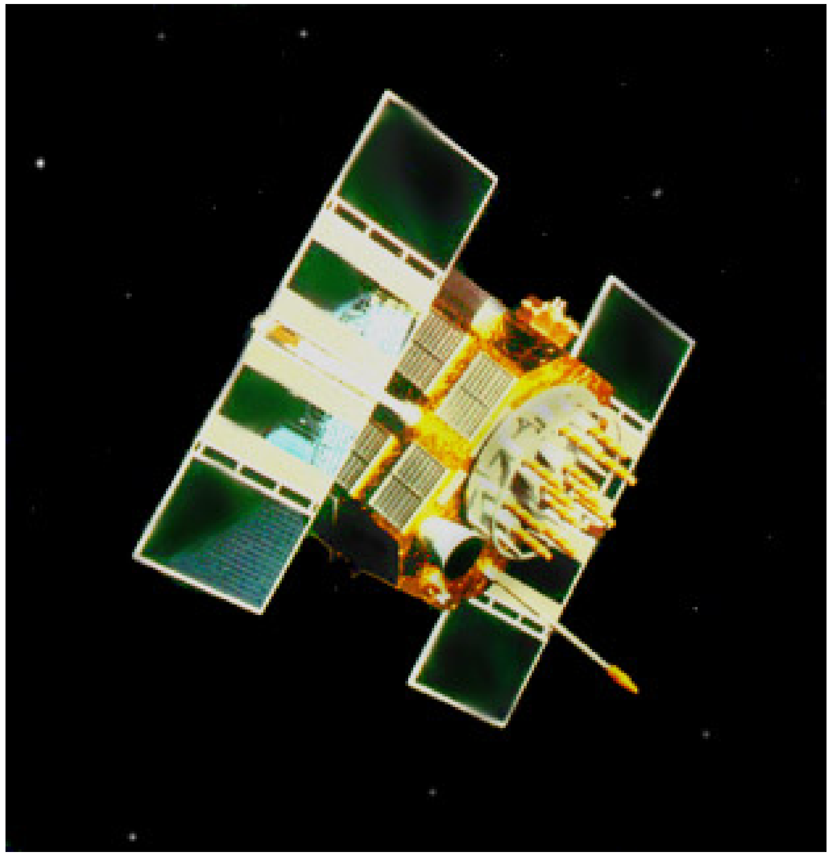
This modernization will require replacing outdated hardware, better use of the available very high frequency (VHF) spectrum, and integrating systems into a seamless network using digital technology. During the transition, the FAA will continue to support analog communications.

Key components of the Communications architecture include:

- **Controller-pilot data link communications (CPDLC) – introduces data exchange between controllers and pilots to reduce voice-channel congestion. CPDLC will be available first from a commercial service provider using VHF digital link (VDL) Mode-2 ground and airborne equipment.**
- **Integrated ground telecommunications infrastructure – a digital infrastructure to provide integrated voice, data, and video connectivity for air traffic control operations and administrative communications.**

Previous Main Next

Navigation



Using Satellite-based Services for Increased Accuracy, Operational Safety, and Airport Coverage

The current aviation navigation system is comprised of more than 4,300 ground-based systems whose signals are used by aircraft avionics for en route navigation and landing guidance. Despite the large number of ground systems, navigation signals do not cover all airports and airspace.

Over the next 10 years, the navigation system is expected to use satellites, augmented by ground monitoring stations, to provide navigation signal coverage throughout the NAS. Reliance on ground-based navigation aids is expected to decline as satellite navigation provides equivalent or better levels of service.

A transition to satellite navigation significantly expands navigation and landing capabilities, improving safety and efficient use of airspace. In addition, it will reduce the FAA's need to replace many aging ground systems, decrease the amount of avionics required to be carried in

aircraft, and simplify navigation and landing procedures.

Previous Main Next

Automatic dependent surveillance-addressable (ADS-A) is designed to support oceanic aeronautical operations, based on communications between aircraft providing ADS information and a ground facility requiring receipt of ADS reports. Aircraft equipped with future air navigation system (FANS-1A) or aeronautical telecommunication network (ATN) avionics exchange identification, flight level, position, velocity, and/or intent data with ADS-A ground equipment through satellite communications. FANS-1A is an integrated suite of communication, navigation, and surveillance avionics.

Automatic dependent surveillance-broadcast (ADS-B) uses satellite navigation and data link to enable aircraft to broadcast information such as identification, position, altitude, velocity, and intent. This broadcast information may be received and processed by other aircraft or ground systems for use in improved situational awareness, conflict avoidance, surveillance, and airspace management.

Surveillance

Installing New Technology and Expanding Coverage

Surveillance in the future NAS will provide coverage in non-radar areas and include aircraft-to-aircraft capabilities for greater situational awareness and safety.

The NAS Architecture calls for evolution from current primary and secondary radar systems to digital radar and automatic dependent surveillance (ADS). This change is designed to improve and extend surveillance coverage and provide the necessary flexibility for Free Flight. The FAA will continue to use primary and secondary surveillance radar to detect and track aircraft in en route and terminal airspace. New radar and surveillance systems will be installed to detect aircraft and vehicles on the airport surface at selected airports.

An ADS system – automatic dependent surveillance-addressable (ADS-A) – will provide surveillance of intercontinental flights in oceanic airspace. When installed in the aircraft and on the ground, possibly starting in 2003, these capabilities and accompanying procedures will increase aviation safety and efficiencies while reducing procedural separation distances.

A new avionics capability – automatic dependent surveillance-broadcast (ADS-B) – may be introduced by the users to provide pilots with an air-to-air surveillance capability in domestic and oceanic airspace. ADS-B avionics under development include a cockpit display of traffic information (CDTI) feature that shows the position of all ADS-B-equipped aircraft to enhance the pilot's awareness of the surrounding environment. As users equip with ADS-B avionics, the FAA will install a compatible ADS ground system. ADS is expected to provide higher capability surveillance services compared to today's radar-based surveillance.

Previous Main Next

Aviation Weather

Integrated terminal weather system (ITWS) is an automated weather system that provides near-term (0-30 minutes) prediction of significant terminal area weather for major terminal locations. ITWS integrates data from radar, sensors, National Weather Service models, and automated aircraft reports. It generates products including windshear and microburst predictions, storm cell hazards, lightning information, and terminal area winds.

Weather and radar processor (WARP) is an integrated system that receives and processes real-time weather data from multiple sources and provides weather information for use by the air route traffic control centers (ARTCC) and air traffic control system command center (ATCSCC) to support the en route environment. It also receives gridded forecast data from the National Weather Service and provides this information to other NAS automation systems. WARP also has direct and indirect connections to the next generation weather radar (NEXRAD) radars and prepares national and regional weather images for the controllers' displays.

Providing Timely and Accurate Weather Data to Controllers and Pilots

Weather conditions interfere with flight operations and contribute to aviation accidents more than any other factor. Given these major impacts, the NAS Architecture contains improved ways to collect, process, transmit, and display weather information to users and service providers, both during flight planning and in flight.

The key to reducing weather-related accidents is by improving pilot decision-making through increased exchange of timely information. Service providers and users will receive depictions of hazardous weather simultaneously, enhancing common situational awareness.

The Aviation Weather architecture will evolve from present-day separate, stand-alone systems to weather systems that are fully integrated into the NAS. The focus is on these two key capabilities:

- **Improved processing/display – with the key systems being the integrated terminal weather system (ITWS) and weather and radar processor (WARP)**
- **Improved sensors/data sources – featuring the next generation weather radar (NEXRAD), terminal doppler weather radar (TDWR), and ground and aircraft-based sensors.**

Improved Processing/Display

Deployment of ITWS and WARP will be completed in Phase 1 of NAS modernization. Both systems will function as weather servers – ITWS in the terminal domain and WARP in the en route domain – acquiring, processing, and disseminating weather products to other subsystems and users.

ITWS provides NEXRAD and TDWR weather radar data and enhanced terminal forecasts to the controller's traffic display at the terminal radar approach control (TRACON)

Previous Main Next

Avionics

Using Satellite-based Navigation and Digital Communications to Improve Safety and Efficiency

Avionics will evolve to take advantage of the benefits found in the new communications, navigation, and surveillance (CNS)-related technologies planned in NAS modernization. With the new avionics, users can use many enhanced services that will help them fly safer and more efficiently.

The pace of modernization will be benefits-driven and dependent on users equipping with these new avionics. The FAA will continue to work with the users to refine transition schedules.

Some of the planned improvements in avionics include:

- **Avionics for the global positioning system (GPS), wide area augmentation system (WAAS), and local area augmentation system (LAAS) to enable aircraft to navigate via direct routes and fly precision instrument approaches to virtually any runway**
- **New multi-mode digital radios for voice and data communications among pilots, controllers, and ground facilities**
- **Automatic dependent surveillance-broadcast (ADS-B) avionics that transmit the GPS-based position, velocity, and intent information to ground stations (air-to-ground) and other aircraft (air-to-air)**
- **Multi-functional cockpit displays to present information, such as graphical weather, notices to airmen (NOTAM), and moving maps, to improve situational awareness.**

Avionics for the global positioning system (GPS)/wide area augmentation system (WAAS) will provide en route and terminal navigation and Category I precision approaches. WAAS increases safety by providing vertical guidance to an aircraft compared to current non-precision approaches which do not.

Avionics for the global positioning system (GPS)/local area augmentation system (LAAS) will provide Category I, II, and III precision approaches and precise surface navigation. Improved surface navigation with moving maps will enable airport operations to continue at near full capacity in limited visibility conditions.

Phase 1 (1998-2002)

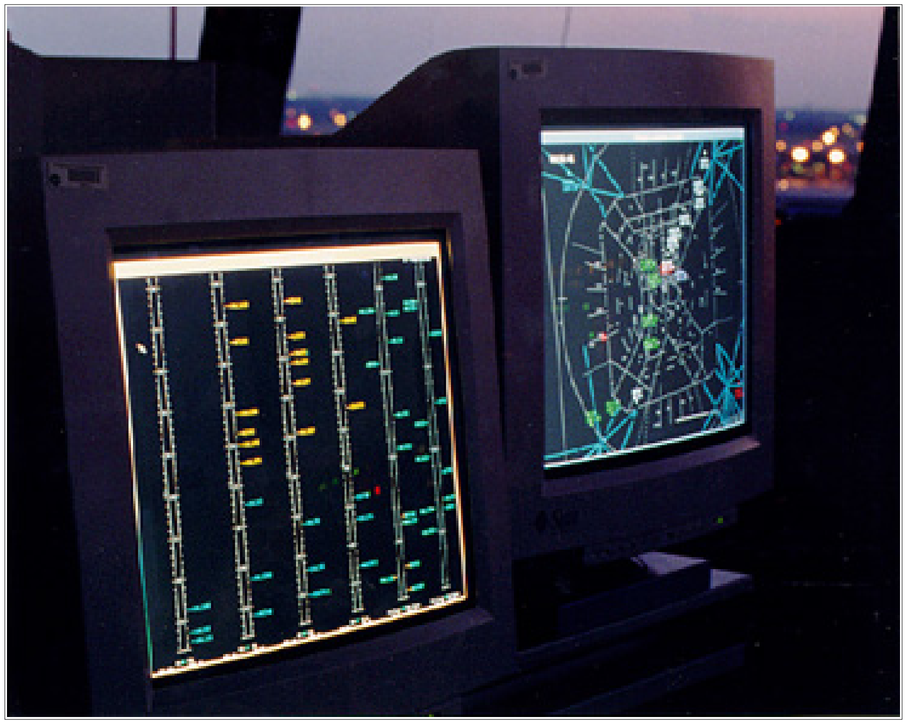
Some GPS avionics are already in use. These receivers are used for en route navigation and non-precision instrument approaches in domestic airspace, provided another navigation system is carried onboard.

GPS combined with WAAS will provide en route and terminal navigation as well as Category (CAT) I precision instrument approach capability to airports.

Controller-pilot data link communications (CPDLC) for routine air traffic control (ATC) messages will be implemented via satellite at all

Previous Main Next

Free Flight Phase 1



Deploying Advanced Automation Capabilities to Accelerate User Benefits and Assess Modernization Risks

Infrastructure Requirements
In order to operate, Free Flight Phase 1 tools depend on infrastructure improvements already underway, such as the host/oceanic computer system replacement (HOCSR), display system replacement (DSR), and standard terminal automation replacement system (STARS).

New tools that give controllers, planners, and service operators more complete information about air traffic control and flight operations comprise a significant part of the NAS Architecture's near-term plan.

Some of these tools are embodied in a program called Free Flight Phase 1 Core Capabilities Limited Deployment. Free Flight Phase 1 is the result of an agreement between the FAA and the aviation community to implement certain highly desired capabilities at selected locations by the end of 2002.

Risk Management

An important objective of Free Flight Phase 1 is to mitigate NAS modernization risks by deploying operational tools at a limited number of sites to evaluate performance, training procedures, human factor requirements and solutions, and safety issues. Users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safety before further deployment. With positive results, each Free Flight Phase 1 tool will be fully developed, integrated, and deployed to suitable locations.

The Free Flight Phase 1 tools are:

- **User request evaluation tool – core capability limited deployment (URET CCLD) for conflict probe**
- **Center TRACON automation system (CTAS) traffic management advisor – single center (TMA SC)**

- **CTAS passive final approach spacing tool (pFAST)**
- **Collaborative decision-making (CDM) with airline operations centers**
- **Surface movement advisor (SMA).**

Previous Main Next

Operational Planning

Sharing Information to More Effectively Manage Flight Planning with a Common View of Traffic Flow

To improve flight planning, the NAS Architecture contains new and improved information services in the areas of traffic flow management and flight services that enable collaboration – service providers and users sharing the same data and negotiating to find the best solutions to meet operational needs.

At the center of this collaboration capability are integrated NAS information services, which include a system-wide computer network, use of standardized data formats, and interoperability across applications, in order to receive and share common data and jointly make planning decisions. The NAS-wide information service will evolve from today's current array of independent systems and varying standards to a shared environment connecting users and providers for traffic flow management, flight services, and aviation weather.

In addition, the flight plan will be replaced by the flight object, which will be designed for dynamic updates and made available to authorized NAS service providers and users to collaboratively manage flight operations. The flight object will contain additional data such as the user's route and altitude preferences, the aircraft's weight, gate assignments, departure/arrival runway preferences, and location while in flight.

The goal of operational planning improvements is to integrate operational and business decisions to gain efficiency, predictability, and flexibility in flight operations.

Traffic Flow Management Improvements

Each day, approximately 100,000 flights use the NAS, requiring many decisions to manage all the traffic. The NAS Architecture provides tools to help users and service providers make collaborative decisions to prioritize and schedule flights and better organize air traffic locally and nationally.

Traffic flow management capabilities are centralized at the air traffic control system command center (ATCSCC). Some functionality is distributed to traffic management units at air route traffic control centers (ARTCC), high-activity terminal radar approach control (TRACON) facilities, and at the highest-activity airport traffic control towers (ATCT).

NAS-wide information service enables data exchange between users and the FAA to facilitate a collaborative response to changing NAS situations, rather than a local solution based on incomplete data. This gives users and service providers a common view of the NAS for improved decision-making during all phases of flight including flight planning.

Previous Main Next

Airport Surface Operations

Moving from Gate to Runway with Greater Safety and Efficiency

At busy airports, numerous aircraft and surface vehicles – fuel trucks, service vehicles, luggage/cargo carriers – operate on the airport surface.

To prevent accidents and maintain flight schedules, the personnel managing airport ground traffic and incoming/outgoing aircraft need accurate and complete information on aircraft and vehicle location and intentions, especially in night and low-visibility conditions. This is possible through a combination of decision support tools, communications and surveillance technology, and new procedures and training.

The airport traffic control tower (ATCT) will evolve from having minimal automation support and relying on visual observations and voice communications between the tower and the users to the following:

- **Information sharing between the FAA and the users via surface movement advisor (SMA)**
- **Expanded use of data link to convey routine information**
- **Surface surveillance tools that help expedite surface traffic and improve safety by reducing runway incursions by surface vehicles and aircraft**
- **Improved radar displays**
- **Improved traffic displays, weather information, and decision support tools to increase airport capacity utilization and mitigate the impact of adverse weather upon airport operations.**

Surface movement advisor (SMA) collects and shares ground movement data on the airport surface with the FAA, airline ramp control operations, and airport management. SMA is one of the automation technologies that will be implemented as part of the Free Flight Phase 1 Core Capability Limited Deployment initiative.

Phase 1 (1998-2002)

The initial SMA, which is part of Free Flight Phase 1, will be installed at selected airports to provide airline ramp control operators with arrival and departure information. Ramp control will be able to improve the sequence and metering of

aircraft movement at gates and on ramp areas.

Previous Main Next

Departures/Arrivals

Maximizing Airport Capacity
Resolving congestion at the busiest U.S. airports requires a combination of modern technology and additional runways. The FAA is working in partnership with airport operators to help plan and develop new runways to accommodate increased aircraft operations, and use new technologies, while meeting environmental requirements.

Standard terminal automation replacement system (STARS) is an all-digital, integrated computer system with modern color displays and distributed processing networks. STARS can be easily upgraded and supports current and future surveillance technology, traffic and weather information, and sequencing and spacing tools. The new STARS workstation will display air traffic, weather overlays, and traffic flow management information for controllers. Future upgrades to STARS tower displays will add a capability to display airport surface traffic and runway incursion alerts and provide the interface for terminal controller-pilot data link communications (CPDLC).

Optimizing Aircraft Sequencing with Improved Controller Tools

Arriving and departing aircraft are sequenced in and out of the airport by air traffic controllers at the terminal radar approach control (TRACON) facilities. Maintaining a steady flow of aircraft, particularly during peak periods, can be improved by providing controllers with tools for sequencing and spacing aircraft more precisely. The objective is to reduce variability in services and optimize use of airspace and available runways.

Focused on maximizing airport capacity, the Terminal architecture will evolve through the installation of improved automation systems to provide the following enhancements:

- On-screen display of terminal weather to improve warnings of hazardous weather conditions
- Improved aircraft sequencing and spacing tools to improve efficiency and predictability of services
- Information sharing with users to improve safety and efficiency
- Information sharing between terminal and en route domains to improve flexibility
- Support for more flexible arrival and departure routes to maximize the use of airport capacity.

The Terminal architecture specifically includes installation of the new standard terminal automation replacement system (STARS) and aircraft sequencing tools.

New Automation System

STARS will be installed at approximately 170 FAA and 36 Department of Defense terminal facilities during Phases 1 and 2 of NAS modernization. STARS capabilities will be phased in incrementally, through a series of pre--planned product improvements.

With its open systems architecture, STARS will interface with advanced communications, navigation, surveillance, and weather systems planned for in the NAS Architecture. STARS will replace the en route automated radar tracking system (micro-EARTS) used in Alaska and at offshore locations. STARS will eventually interface with the airport movement area

Previous Main Next

En Route/Oceanic

Upgrading Automation to Share Data and Improve Operating Efficiencies

The evolution toward a Free Flight environment requires significant improvements in en route and oceanic computer systems and controller decision support tools. The aging automation infrastructure must be replaced before new applications and improved services can be provided.

Currently, en route and oceanic facilities are co-located but do not share common systems, primarily because of the lack of surveillance and direct communications services over the ocean. The addition of oceanic surveillance and real-time direct communications will enable oceanic services to gradually become comparable with en route services, and oceanic and en route systems will evolve to a common hardware and software environment.

In the domestic airspace, aircraft are radar-monitored and typically follow the fixed route structure of airways, preventing pilots from flying the most direct route or taking advantage of favorable winds.

Previous Main Next

U.S. Department
of Transportation
Federal Aviation
Administration

Office of the Administrator

800 Independence Ave., S.W.
Washington, D.C. 20591

January 1999

Dear Members of the Aviation Community:

I am pleased to present the ***Blueprint for NAS Modernization***, an overview of the Federal Aviation Administration (FAA) National Airspace System (NAS) Architecture Version 4.0. It is a summary of the more comprehensive NAS Architecture, a 385-page document that is being released simultaneously.

The NAS Architecture is the U.S. aviation community's comprehensive, long-term plan for improving the NAS. The plan provides users and service providers with more efficient services and new capabilities that will enhance the safety of our aviation system over the next two decades.

This plan is based on the joint FAA and industry's operational concept for planning and conducting flights with greater safety, flexibility, and efficiency. The NAS Architecture is a rational, affordable, and feasible plan to meet user requirements during a time of significant growth in air transportation. The NAS Architecture also reflects the realities of the FAA budget.

The NAS Architecture will guide the FAA's budget and delivery of NAS services, ensuring that the agency makes sound business decisions to meet users' needs. The NAS Architecture also is a valuable resource to help users and manufacturers plan their operations and investments with confidence.

Many people, representing all facets of the aviation community, contributed to the development of the NAS Architecture. The participation across the industry was a crucial ingredient to the overall effort. The consensus across Government and industry is that the NAS must be modernized to meet America's demand for continued safe, secure, and efficient air travel. The NAS Architecture is our roadmap for achieving that goal, and we are committed to following the plan in concert with our customers, the aviation community.

Jane F. Garvey
Administrator

Main Next